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## EVALUATION OF PATIENTS FOR PULMONARY EMBOLLECTOMY

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The availability of modern embolectomy highlights the difficulty of diagnosing pulmonary embolism. Premonitory leg signs are often absent. The ordinary chest Xray and the electrocardiogram are frequently not helpful or even misleading. There is little comfort to be had from an electrocardiographic diagnosis of myocardial infarction if autopsy discloses massive pulmonary embolism. The differentiation between pulmonary embolus and myocardial infarct, an interesting exercise in the anticoagulant era, is mandatory if embolectomy is possible.

When pulmonary embolism is fairly certain on clinical grounds alone, should the patient be put on bypass for embolectomy? Perhaps caval interruption to prevent further embolization is all that is necessary. We believe that decision regarding treatment can be based on three things: 1) the clinical status of the patient, 2) the pulmonary artery pressure, and 3) the degree of pulmonary arterial obstruction as demonstrated by pulmonary arteriograms.

### THE TIME FACTOR IN FATAL PULMONARY EMBOLISM

The objection is often raised that, as pulmonary embolism is a rapidly fatal condition, not enough time is available for introduction of a cardiac catheter and performance of pulmonary angiograms. In assessing this consideration, 10 recent cases of fatal pulmonary embolism proved at autopsy at the Henry Ford Hospital were reviewed (Table 1). The time elapsing between onset of symptoms sufficient to cause suspicion of pulmonary embolism and the patient's death was 6½ hours in one case, 24 to 48 hours in six cases and 6 to 8 days in two cases. Only one patient died suddenly — in 1½ hours. In all but one of the 10 cases, ample time elapsed between the onset of symptoms and death in which angiograms could have been done and treatment instituted. A representative case is recorded:

*Case No. 1* A 45-year old man had a transthoracic repair of a large recurrent hiatus hernia which had been operated on three times previously through the abdomen. The patient also had a large ventral hernia. Two days after operation, the patient was found cyanotic with a pulse of 130 without chest pain or dyspnea. There was

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Table I

## Ten Cases of Fatal Pulmonary Embolism

Patients	Time Elapsed Between Symptoms and Death
2	6 - 8 days
6	24 - 48 hours
1	6½ hours
1	1½ hours

no calf tenderness or ankle edema. An electrocardiogram was interpreted as showing posterior myocardial infarction. Oxygen therapy and digitalis were administered. At 6:00 a.m. on the fourth postoperative day, the patient died. At autopsy, large coiled obstructing emboli were found in the pulmonary arteries. Time between symptoms and death: 2 days.

## ANGIOGRAMS IN DIFFERENTIAL DIAGNOSIS

The differentiation between myocardial infarction and pulmonary embolism is notoriously difficult. We have learned the hard way that electrocardiograms cannot be relied upon to make this differentiation. There have been misgivings as to the safety of pulmonary angiography in patients with myocardial infarction. Obviously this is just where the diagnosis must be made with the greatest exactness. We have found pulmonary angiograms to be well tolerated in patients with myocardial infarction.

*Case No. 2* A 52-year old man collapsed in the emergency room where he had brought his daughter for treatment. Artificial ventilation and external cardiac massage were started. Ventricular fibrillation was converted by external electrodes. Upon awakening, the patient complained of dyspnea and was cyanotic. Electrocardiograms showed right bundle branch block and ST segment changes. Pulmonary embolus was suspected. Angiograms were done with a catheter in the pulmonary artery. The pulmonary arteries were free of any obstruction. Pulmonary artery pressure was 22/6 mm. of Hg. and wedge pressures were zero. The patient was treated for myocardial infarction. He had several subsequent attacks of angina, particularly after becoming ambulatory. He was later discharged from the hospital and is now being treated as an outpatient for left shoulder pain.

There are other clinical situations where disproving the diagnosis of pulmonary embolism can be lifesaving to the patient as exemplified by the following case.

*Case No. 3* A 50-year old woman was transferred from another hospital in critical condition with a diagnosis of pulmonary embolism and severe bleeding per rectum. The patient had had a segmental small bowel resection for a bleeding hemangioma. Following operation, she became dyspneic and hypotensive and was thought to have a pulmonary embolus. Heparin therapy was begun with apparent improvement in the dyspnea but with the development of massive gastrointestinal hemorrhage. Angiograms done immediately on admission showed complete patency of the pulmonary



## PULMONARY EMBOLECTOMY

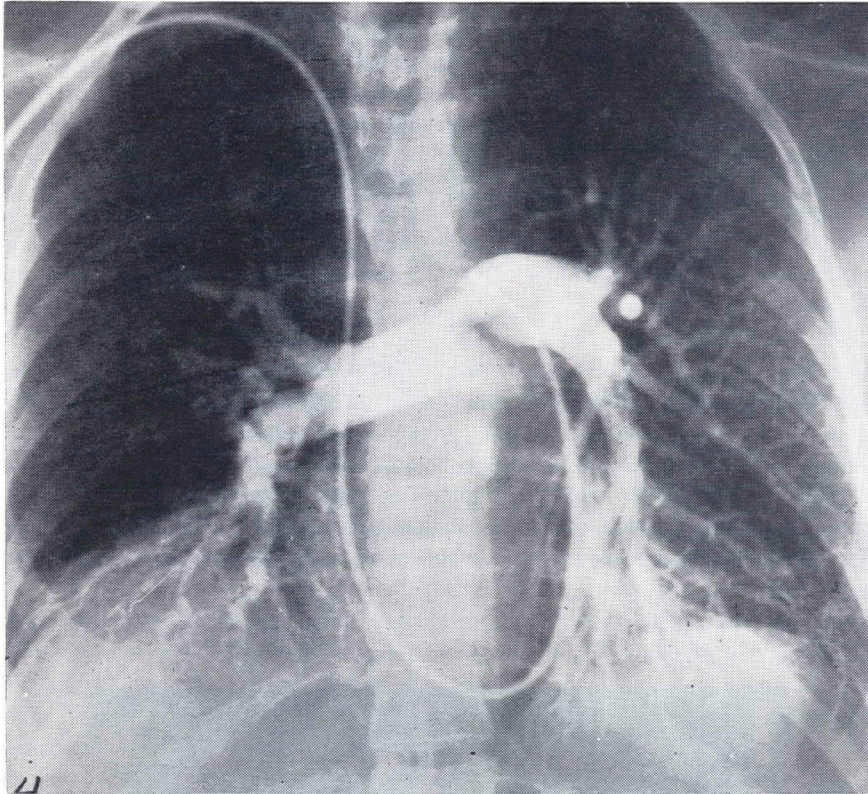


Figure 1

Pulmonary arteriogram in patient suspected of pulmonary embolism. No emboli are demonstrated but there is bilateral lower lobe atelectasis manifested by crowding together of the lower lobe vessels.

arterial bed with crowding together of the lower lobe vessels compatible with bilateral lower lobe atelectasis (Fig. 1). The heparin was promptly discontinued, blood lost was replaced and she was treated with oxygen inhalations and endotracheal suction to expand her collapsed lower lobes. She gradually improved and was discharged well.

### INDICATIONS FOR CAVAL INTERRUPTION ONLY

Angiographically proved pulmonary embolism is not necessarily a mandate for embolectomy. If only a small portion of the pulmonary arterial bed is occluded and there is no elevation of pulmonary artery pressure, caval interruption to prevent further emboli is the treatment of choice.

*Case No. 4.* A 50-year old man was admitted with a swollen, tender calf, chest pain and hemoptysis. He had a tachycardia of 150 per minute and was dyspneic. Pulmonary angiograms demonstrated filling defects in the right lower lobe artery. The pulmonary artery pressure was 24/9 mm. of Hg. The vena cava was interrupted



with a serrated plastic clip below the renal veins. The patient's pulmonary difficulties slowly resolved and he was discharged. When seen as an outpatient he had no leg edema.

#### INDICATIONS FOR EARLY EMBOLECTOMY

When a patient sustains a pulmonary embolization and has hypotension, tachycardia, dyspnea, and cyanosis, preparations for embolectomy should be made. If in addition there is elevation of the pulmonary artery pressure and pulmonary angiograms show occlusion of 60 to 70 percent of the arterial bed, bypass embolectomy should be carried out without delay.

*Case No. 5.* An 80-year old man had a right upper lobectomy for a benign tumor. On the 15th postoperative day he was found collapsed in the bathroom, severely dyspneic. He was cyanotic and his systolic blood pressure was 70 mm. of Hg. Pulmonary angiograms showed multiple bilateral occlusions (Fig. 2). The pulmonary artery pressure was 50/15. With cardiopulmonary bypass, large emboli were removed from both pulmonary arteries and the inferior vena cava was interrupted with a plastic clip below the renal arteries. He tolerated the procedure well and was ambulatory five days later.

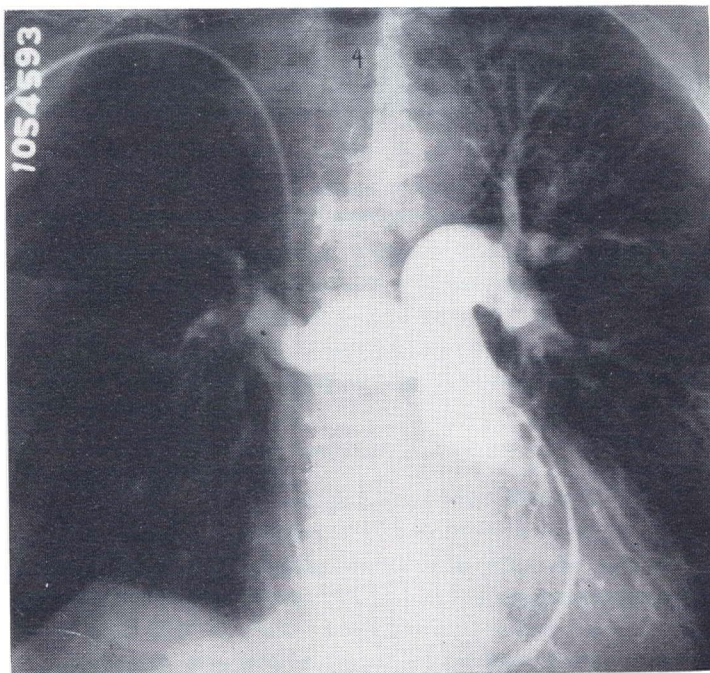


Figure 2

Pulmonary angiogram of patient showing extensive bilateral embolic obstruction of the pulmonary arteries 15 days after right upper lobectomy.

## PULMONARY EMBOLECTOMY

Pulmonary artery pressure elevations such as seen in pulmonary hypertensive states of gradual onset are probably not to be expected often in acute pulmonary embolism. A twofold increase in the systolic level is indicative of very severe obstruction when one considers that pneumonectomy seldom produces this degree of pressure increase. Pulmonary artery pressure measurement alone as advocated by Wilman and Hanlon<sup>1</sup> is not sufficient to allow one to proceed with embolectomy, however. A patient with myocardial infarction proved at autopsy and no pulmonary emboli had a pulmonary artery pressure of 50/20. In addition, two patients with proved infarction had no elevation of pulmonary artery wedge pressures.

### TECHNIQUES OF EMBOLECTOMY

Disposable oxygenators primed with glucose and water have provided a great impetus to pulmonary embolectomy.<sup>2</sup> The instant availability of an oxygenator unit allows the patient to be taken to the operating room for embolectomy as soon as the decision is made. Small portable oxygenators designed for partial bypass with femoro-femoral cannulation under local anesthesia have been less attractive to us. To begin a perfusion in a remote corner of the hospital and then transport the patient with a functioning perfusion to the operating room without mishap seems unlikely.

We believe our chances for success to be greater with emphasis on early diagnosis and prompt transportation of the patient to the angiogram room which is adjacent to the operating room. While the angiograms are done, the operating room is set up. The patient can then be moved directly to the operating room if embolectomy is decided upon.

In addition, there are technical considerations which limit the use of femoro-femoral cannulation. For example, in a recent successful bypass embolectomy, cannulation of the femoral vein was impossible because the common femoral vein was filled with thrombus.

*Case No. 6.* A 59-year old man entered the hospital for elective perineal prostatectomy for benign prostatic hypertrophy. He had had phlebothrombosis of the legs for many years, and had been previously hospitalized for respiratory difficulty thought due to small pulmonary emboli. On the seventh day after prostatectomy, he developed swelling of the legs and on the 11th postoperative day, acute chest pain. A bilateral femoral vein ligation was done, but the patient had increasingly severe dyspnea, tachypnea, cyanosis and hypertension. Pulmonary angiograms on the 13th postoperative day showed extensive bilateral pulmonary arterial obstruction. Pulmonary embolectomy with cardiopulmonary bypass was carried out. Branching emboli in the distal pulmonary arterial tree were removed by retrograde injection of fibrinolytic and saline into the pulmonary veins followed by compression of the lungs. Epsilon aminocaproic acid was used to control what seemed to be excessive bleeding during the chest wall closure. Tracheostomy was performed electively and ventilatory assistance with a Bennett ventilator was employed. Following operation, the patient made a gradual recovery and is well at this time several months later.



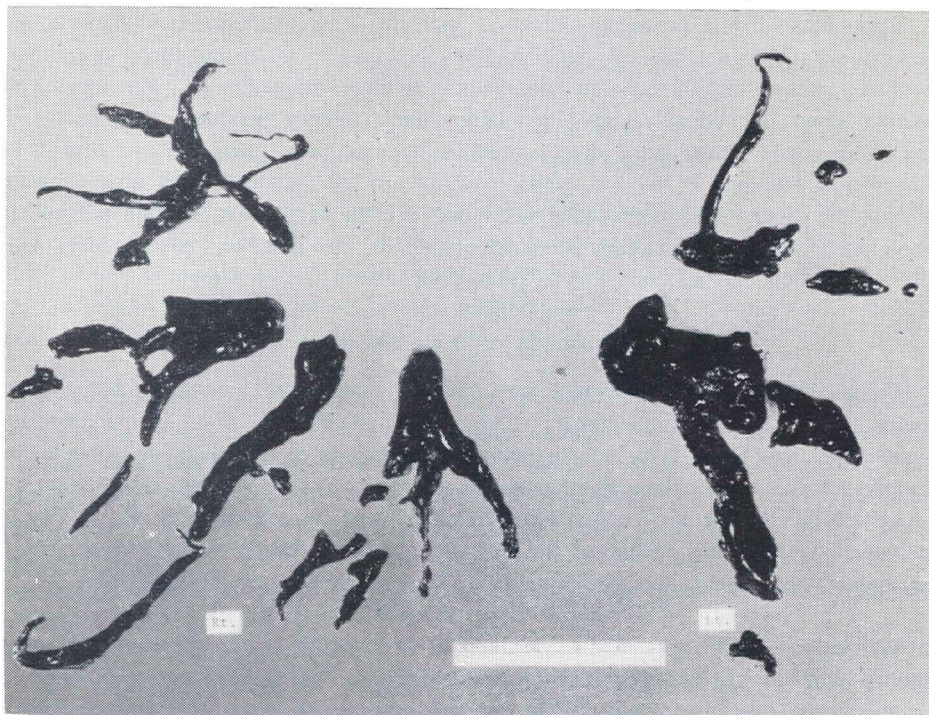


Figure 3

Emboli removed from patient during cardiopulmonary bypass with retrograde fibrinolysin injection into the pulmonary veins. Arranged in anatomical position at time of removal.

We have used fibrinolysin by pulmonary venous injection in two embolectomies with apparent aid in removal of distal emboli (Fig. 3). The pulmonary veins were clamped at their entrance into the atrium and 50,000 units of fibrinolysin dissolved in saline were injected retrograde. After 15 minutes, saline irrigation of the veins combined with manual compression of the lungs expressed emboli out of the open pulmonary artery. Entrance of fibrinolysin into the systemic circulation does not occur while the lungs are bypassed, but may occur on termination of bypass if any remains in the pulmonary circuit. In one patient, a large man with a very deep chest, access to the pulmonary veins was difficult and probable inadequate removal of fibrinolysin resulted in considerable oozing at the conclusion of the pump run. Injection of aminocaproic acid following protaminization controlled the bleeding satisfactorily. Pulmonary edema was not a problem postoperatively in either case.

Protection from further emboli following embolectomy is afforded by caval interruption for which we have used a serrated plastic clip applied below the renal veins. Anticoagulants may be given after the first postoperative days to minimize leg complications of caval interruption. Elective tracheostomy for efficient tracheo-bronchial suctioning and ventilator assistance is indicated particularly in patients with preoperative hemoptysis indicative of parenchymal infarction.

## PULMONARY EMBOLECTOMY

### CONCLUSIONS

Pulmonary angiograms are done in all patients suspected of pulmonary embolism. The decision for treatment is based on 1) the condition of the patient, 2) the pulmonary artery pressure and 3) the amount of pulmonary arterial obstruction as shown by angiograms. If the patient has normal vital signs without dyspnea and cyanosis, no elevation of pulmonary arterial pressure and only a small portion of the pulmonary vascular bed occluded, caval interruption alone is indicated. If the vital signs are altered, the pulmonary arterial pressure is elevated and there is 60 to 70 percent occlusion of the pulmonary arterial tree, immediate embolectomy with cardiopulmonary bypass is indicated.

### ACKNOWLEDGEMENTS

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The epsilon aminocaproic acid was supplied as Amicar through the courtesy of Malcolm H. Fine, M.D., Lederle Laboratories, Cincinnati, Ohio.

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